LINK WRITING METHOD FOR A RECORDABLE COMPACT DISK AND DRIVER FOR USING THE METHOD

BACKGROUND OF THE INVENTION

1.Field of the Invention:

This invention relates to a writing method and device for a recordable compact disk (CD-R), and more particularly, to a link writing method and device with the function for succeeding writing the interrupted recording CD-R.

2. Description of Related Art:

Optical disk media typically include a continuous spiral groove which extends for the entire data storage capacity of the disk. CD-based (CD-R or DVD-R) optical disk media architecture utilizes the continuous spiral groove with sectors (also called "block") of equal length, which are accessed at a constant linear velocity (CLV).

A recordable compact disk (CD-Recordable or CD-R) or a rewritable compact disk (CD-Rewritable or CD-RW) is a CD based medium, and includes a continuous spiral CLV groove. Input data are modulated and wrote into the continuous spiral CLV groove. In general, the coding modulation of CD-R is an 8-14 modulation (EFM, eight-to-fourteen modulation). The so-called EFM is to turns the input signal, along with error correction data, address information, Sync pattern (synchronization pattern), and other miscellaneous content, into an encoded binary stream of bits, expanding every eight bits of input data into fourteen, with an additional three bits to separate words.

Fig. 1 shows the data specification for each recording sector in CD-based medium. As shown in Fig.1, each recording second includes 75 recording blocks and each of recording blocks includes 98 data frames. Moreover, each of the data frames includes 588 channel bits which are constituted by a Sync pattern containing 24 channel bits, control and display data containing 14 channel bits, information data, and the correction parity etc. Since the CD-R does not provide the identification marks to identify data recording positions precisely, each recording sector are therefore formatted with headers

having a great deal of information to aid in synchronizing the rotation of the disk and obtaining data framing, including a great deal of overhead. Moreover, a limited number of entries may be placed in the table of contents (TOC) on the disk for locating the beginning of the recorded areas. Therefore, it is very important for CD-R not to interrupt the data writing process because of the overhead penalty.

Current CD-R devices therefore have a buffer to accumulate the input data to organize the data into sectors for writing on the disk in a continuous sequence of sectors. When the current buffer of a CD-R device fails to receive input data from the host on a timely basis (due to higher priority tasks or interrupts using host resources), the buffer may under-run and will become empty, causing the writing process to be halted in an orderly fashion. This will results in a data file being partially written. One proposed solution, which is undesirable, is to stop writing sectors upon the occurrence of the under-run. It is not possible to restart the writing process due to that the succeeding recording position can not be located precisely. Most often, the user application cannot deal with the linking problem between prior recording process and succeeding recording process, so the disk is considered ruined and discarded.

In the light of this problem, the U.S. Patent No. 6,119,201 disclosed a method of employing a formatted padding sector to resolve the under-run problem. The method disclosed by the patent is to write one or several formatted padding sectors for substituting and replenishing the under-run. While the method can resolve the under-run problem without stopping writing, it wastes the disk's sector as it requires to replenish one or a multiple of formatted padding sector. Moreover, the method wastes time in reading since it needs to judge if the data need to replenish. What is more, the method can not overcome the problem of writing interruption caused by the servo problem.

Therefore, it is necessary to have a link writing method and device for a recordable compact disk to directly succeed the writing process at the address where it is interrupted. This is to effectively resolve the problems of writing interruption caused by the under-run or other problems.

Fig. 2 is the situation that the data frame of the succeeding writing overlaps the previous data frame according to a prior art. As the demand on the length of the data frame of the CD-based medium is rigorous, the length of the data frame has to set as 588T (bits) in order to correctly read the data written. But as shown in Fig. 2, if the (n+1) th data frame that is written before the interruption is overlapped by (n+2) th data frame causing the inability to differentiate the two data, reading error of the data will occurs. As shown in Fig. 2, either range (A) is treated as two frames or range (B) is treated as one frame will cause data reading error.

Moreover, Fig. 3 is the situation that the data frame of the succeeding writing forms a gap with the previous data frame according to a prior art. As shown in Fig. 3, whenever a linking gap appears between the succeeding written (n+1)th frame and the written n th frame when interrupted, reading error also occurs. This is because that the linking gap has redundant channel bits, thereby, causing the inability of the access driver to differentiate the data frames when it is reading. For instance, as shown in Fig. 3, either range (A) is treated as two frames or range (B) is treated as one frame will cause data acquisition error. Therefore, it is very important to position the writing interruption address accurately and to succeed writing accurately.

SUMMARY OF THE INVENTION

It is therefore an objective of the invention to provide a link writing method for a recordable compact disk (CD-R) and a driver for using the method for resolving the problem of writing interruption resulted from data under-run or other causes during the writing process of the recordable compact disk.

According to an aspect of the invention, there is provided a link writing method for a recordable compact disk (CD-R), comprising the steps of: recording a interrupted position by storing values of an interrupted sector, an interrupted data frame, and an interrupted bit count when data under-run or other causes occur in the driver; and enabling a succeeding writing process when the causes causing the writing interruption is eliminated. The step of succeeding writing process comprising positioning a linking

area in accordance with the values of the interrupted sector, the interrupted data frame, and the interrupted bit count; enabling the start writing signal; and settling the laser power. The linking area comprises the steps of:

(1) reading the values of the interrupted sector, the interrupted data frame, and the interrupted bit count of the interrupted position;

(2) setting the linking position, including starting sector, starting frame and starting bit count;

(3) searching the interrupted sector area by counting the sector's SYNC signal to the starting sector;

(4) searching the interrupted data frame area by counting the EMF's SYNC signal to the starting frame; and

(5) searching the interrupted bit area by counting the EFMCLK's pulse signal to the starting bit count.

Therefore, the linking area is linked to the interrupted position accurately and the length of the data frame is kept constant without causing errors on data reading.

BRIEF DESCRIPTION OF DRAWINGS

The objectives, characteristics, and advantages of the present invention can be more fully understood by reading the following detailed description of the preferred embodiment, with reference made to the accompanying drawings as follows:

Fig. 1 shows the data specification for each recording sector according to a prior art.

Fig. 2 is the situation that the data frame of the succeeding writing overlaps the previous data frame according to a prior art.

Fig. 3 is the situation that the data frame of the succeeding writing forms a gap with the previous data frame according to a prior art.

Fig 4 is a block diagram of the recordable compact disk driver of the invention.

Fig 5 is a flow chart for detecting the linking area of an embodiment of the invention.

Fig 6 is a flow chart for detecting the linking area of another embodiment of the invention.

Fig. 7 is the correct linking situation between the data frame of the succeeding writing and the previous data frame making use of the embodiments in Fig. 5 and Fig. 6 according to the invention.

Fig. 8 is a flow chart for detecting the linking area of one other embodiment of the invention.

Fig. 9 is the correct linking situation between the data frame of the succeeding writing and the previous data frame making use of the embodiment in Fig. 8 according to the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

The link driving method of a recordable compact disk having succeeding writing function of the invention firstly employs an encoding link controller to precisely position the linking area, then enables writing start signal in order to commence succeeding writing process. Following is the description of the invention accompanied by the drawings.

Fig. 4 is a block diagram of the recordable compact disk driver having succeeding writing function according to the present invention. As shown in Fig. 4, the recordable compact disk driver 10 includes a host interface 12, a memory controller 14, a CD-ROM decoder 16, a CIRC decoder 18, a sub-code decoder 20. It also includes an EFM demodulator 22, a SYNC pattern detector 24, a data slicer 26, a servo controller 28, an ATIP decoder 30, an encode link controller 32, a CD-ROM encoder 34, a CIRC encoder 36, a sub-code encoder 38, an EMF modulator 40, a writing circuit 42, and a micro controller 44. The functions of most of the units shown in Fig. 4 are the same as those of the recordable compact disk driving device of the prior art. The only difference is that the encoding link controller 32 included in the invention can be used to precisely position the predetermined writing address (linking area) according to the position information signals generated from the SYNC pattern detector 24, sub-code

decoder 20 and ATIP decoder 30. When the encoding link controller 32 detects the linking area, it generates a "start writing signal" to the micro controller 44 so as to perform the action of succeeding writing. The function of the sub-code decoder 20 is to detect and output the time position information of the recorded block, while the function of the ATIP decoder 30 is to detect and output the ATIP time code (MSF information, Minute, Second, Frame) beforehand recorded or blank discs.

Two detecting methods are provided to precisely detect the linking area according to the present invention. The first one is "data decoding method" while the other one is "blank area identifying method". The "data decoding method" makes use of a decoding circuit to count the block, the frame, and the channel bits of the previous recording ending position to precisely detect the interrupted position as the linking area. The decoding circuit can firstly search the ATIP identifying data (MSF information) of the linking area and then precisely detect the linking area by counting the channel bits. The "blank area identifying method" is to detect the non-recording or blank location as the linking area.

Generally speaking, whenever the write error of the recordable compact disk driver occurs such as under-run or servo error, the driver will enable the write error signal and stop the write action. The driver of the invention, in the mean time, also stores the write interruption address into registers. The data of the write interruption address include current time code of the block (also called MSF, Minute and Second Frame), current counted value of the EFM frame, and current counted value of EFM channel bit. These data are stored into the MSF register, the EFM_SYNC_CNT register, and the EFM_BIT_CNT register, respectively. The encoding link controller 32 can thereby use the write interruption address as the start address index when it comes to succeeding writing in order to precisely locate the linking area.

Three stages are used to precisely detect the linking area by the encoding link controller 32. The first stage is the MSF counting, the second stage is the frame counting, and the third stage is the channel bit counting. The driver 10, after reading sufficient data or overcoming the interruption problem, will enable the succeeding

writing process and start the encoding link controller 32, and in the same time, read the written area on the disk sequentially. Then, encoding link controller 32 will precisely position the linking area in accordance with the position information signals generated by the SYNC pattern detector 24 and the sub-code detector 20. Thereafter, the encoding link controller 32 sends the start writing signal to the micro controller 44 to perform the action of succeeding writing. Fig. 5 is an embodiment of flow chart for detecting the linking area. In referring to Fig. 5, the action of the encoding link controller 32 is described as follows:

Step S500: Start the succeeding Write.

Step S502: Read the data from MSF, EFM_SYNC_CNT, and EFM_BIT_CNT registers and the positional data are used as the starting address of the linking area.

Step S504: Perform the first stage counting and start the MSF counter.

Step S506: Count the output signal generated from the sub-code decoder 20 by the MSF counter.

Step S508: Compare if the counted value of the MSF counter has already equaled to the value in the MSF register. If it has, jumps to step S510, otherwise, jumps back to step S506.

Step S510: Perform the second stage counting and start the frame counter

Step S512: Count the output signal generated from the SYNC pattern detector 24 by the frame counter.

Step S514: Compare if the counted value of the frame counter has already equaled to the value in the EFM_SYNC_CNT register. If it has, jumps to step S516, otherwise, jumps back to step S512.

Step S516: Perform the third stage counting and start the Bit counter.

Step S518: Count the pulse signal of the EFMCLK by the bit counter.

Step S520: Compare if the counted value of the bit counter has already equaled to the value in the EFM_BIT_CNT register. If it has, jumps to step S522, otherwise, jumps back to step S518.

Step S522: Enable a WRITE_START signal and activate the writing laser power.

Moreover, the steps shown in Fig. 5 make use of the sub-code decoder 20 to detect the written block time code and position the linking area that is interrupted. Besides using this method, the invention also presents a method making use of ATIP decoder 30 to detect the ATIP time code which is pressed in advance, and to locate the linking block that is interrupted.

By the use of this method for locating the linking area, the driver will store the address of the writing interruption area into registers. The process for storing data includes storing the counted value of the current block into the MSF register, and storing the block's written bit into the BIT_CNT register. Afterward, the encoding link controller 32 can make use of the value of the registers as the index of starting address to locate precisely the linking area for succeeding writing.

Two stages are used to precisely locate the linking area by the encoding link controller 32. The first stage is the MSF counting, and the second stage is the channel bit counting. The driver 10, after reading sufficient data or overcoming the interruption problem, will enable the succeeding writing process and start the encoding link controller 32. Then, encoding link controller 32 will precisely position the linking area in accordance with the output signals of the ATIP detector 30 and the EFMCLK pulse. Thereafter, the start writing signal is transmitted to the micro controller 44 to perform the action of succeeding writing. Fig. 6 is an another embodiment of flow chart for detecting the linking area of the invention. In referring to Fig. 6, the action of the encoding link controller 32 is described as follows:

Step S600: Start the succeeding Write.

Step S602: Read the data from MSF and BIT_CNT registers and the data are used as the positional data for detecting the linking area.

Step S604: Perform the first stage counting and start the ATIP search.

Step S606: Make use of the ATIP decoder 30 to search each of the MSF time code of ATIP sequentially.

Step S608: Compare if the value of the ATIP time code has already equaled to the value in the MSF register. If it has, jumps to step S610, otherwise, jumps back to step

S606.

Step S610: Perform the second stage counting and start the bit counter.

Step S612: Count the EFMCLK pulse signal by the bit counter.

Step S614: Compare if the counted value of the bit counter has already equaled to the value in the BIT_CNT register. If it has, jumps to step S616, otherwise, jumps back to step S612.

Step S616: Enable a WRITE_START signal and activate the writing laser power.

Therefore, after the linking area is located by the above-mentioned methods, the encoding link controller 32 activates the writing laser immediately and enables the WRITE_START signal. Moreover, the succeeding writing action is started as soon as the micro controller 40 of the driver 10 receives the "WRITE_START" signal. As the encoding link controller 32 includes three stages of counting, the accuracy of the linking position can be controlled within one bit. Therefore, the starting address of the succeeding writing will not be overlapped with the written data interrupted, nor will it be formed a gap with the written data.

Fig. 7 is the correct writing situation between the data frame of the succeeding writing and the previous data frame making use of the embodiments in Fig. 5 and Fig. 6. Assume that up to the n^{th} data frame is written and then stopped by the driver 10 because of the under-run. Afterward, when the driver 10 read sufficient data from the host such that the writing action can be continued, the driver 10 enables the encoding link controller 32. In this way, the driver 10 can perform the writing action immediately and writing the $(n+1)^{th}$ data frame and the subsequent data frame when the optic head is driven to the linking area. So the driver 10 can finish the recording (writing) procedure as no interruption occurrence, and no any data miss between the two recordings. Again, as shown in Fig. 7, the succeeding writing of the $(n+1)^{th}$ data frame will not overlap with the n^{th} data frame written by previous interrupted recording. Moreover, the $(n+1)^{th}$ data frame will not form a blank gap either with the n^{th} data frame. Consequently, the length of the data frame can be controlled within 588T without causing data acquisition error.

Due to the data recorded on disc is incomplete during write laser power settling stage, this will cause data grabbing error. If the succeeding recording start position is same as the stop position of previous recording procedure, the range of erroneous data is the write laser power settling time. If the write laser power settling time can be determined, the driver 10 can advance the succeeding recording start position according to the settling time. Then the previous recording data and succeeding recording data will overlap at the initial position of succeeding writing. Because the laser power in not enough (during the settling time) in the overlap area, the data at the overlap area will not be destroyed. If the write laser power settling time can be estimated accurately, then the error data number can be downed to "0" ideally. If the write laser power settling time is estimated in error, a common driver can correct the partially erroneous bit data by the CIRC decoding process. As a result, although a portion of the bit data in the invention is unstable before the laser light source is stabilized, this unstable bit data will not cause erroneous reading of the data since the unstable bit data can be corrected by the CIRC decoding process.

Following is the explanation of the principle of the "blank area identifying method" of the invention. Since a common storing medium of the "write-once disk" has relatively high reflectivity, the reflected "radio frequency" (RF) signal maintains on a relatively high level of reflectivity. And since the maximum run-length (MRL) of the EFM data is limited to a constant range, e.g. 11T for CD format, the data length will be greater than the MRL value when the data of the blank area (unwritten area) are acquired by the driver. Therefore, the blank area can be detected by judging whether or not the data acquired is greater than the maximum run-length. The "blank area identifying method" of the invention is employed to detect the blank area that is used as the linking area of the succeeding writing. Fig. 8 is a flow chart for detecting the linking area of one other embodiment of the invention. As referring to Fig. 8, the illustration of the "blank area identifying method" of the invention is as follows:

Step S800: Start the succeeding Write.

Step S802: Set MRL.

Step S804: Read the register data EFM_BIT_CNT and add the MRL to the register data to assure the correct length of the data frame.

Step S806: Judge if the data acquired is greater than the MRL. If it is so, jumps to step S808, otherwise, continue the step.

Step S808: Enable a WRITE_START signal and settle a writing laser power.

While making use of the "blank area identifying method" in detecting the blank area, since the detected area has exceeded the MRL's bit number, so Step 804 is employed to add the MRL to the EFM_BIT_CNT register data as recording preset length to assure the correct length of the data frame. Fig. 9 is the correct linking situation between the data frame of the succeeding writing and the previous recording data frame. As shown in Fig. 9, although the method also generates a portion of blank data (the MRL plus the laser power settling time), since the bit number of the linking frame still remains correct length, such as 588T, the blank area can still be corrected by the CIRC decoding process.

Furthermore, as far as the write-once disc is concerned, since all the blank area belongs to an area with relatively high reflectivity, the blank area after the writing interruption can be detected accurately by employing the "blank area identifying method". Nevertheless, as far as the Re-Writable disk is concerned, since the data can be over-written directly in the data area, the linking area after the writing interruption can not be identified by directly employing the "blank area identifying method". In order to be able to identify the linking area for the Re-Writable disk after writing interruption by the use of the "blank area identifying method", a section of pattern data has to be written after the writing interruption. And the section of pattern data must have the same reflectivity and have data length greater than the MRL. In this way, the pattern data can then be employed by the "blank area identifying method" to identify the linking area after the writing interruption.

To summarize the foregoing statement, the link writing method for a recordable compact disk and the driver for using the method of the invention makes use of the encoding link controller to precisely detect the linking area, and starts the succeeding

writing process. Therefore, it can continue to finish the writing action to assure that the length of each data frame is constant when data under-run or some other servo problems occur. Due to the data frame length keep constant, such as 588T, during linking area, this can be treated as non-interrupted recording area and will not appear decoding error during reading cycle. Moreover, since the link writing method for a recordable compact disk and the driver for using the method of the invention directly connects the data after being interrupted, it is treated as normal recording procedure and no any retrievement needed.

The invention has been described using an exemplary preferred embodiment. However, it is to be understood that the scope of the invention is not limited to the disclosed embodiment. On the contrary, it is intended to cover various modifications and similar arrangements. The scope of the claims, therefore, should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.